Design Guidelines

FOR THE

TYPE BASIC & BASIC CAB CRITICAL POWER DISTRIBUTION SYSTEM (CPDS)

Contract Number

CONTRACTOR

CACI (Paradigm Solutions)

1100 North Glebe Road
Arlington, VA

Design Guidelines developed for

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

January 25, 2012

Table of Contents

Table of Contents iii

SECTION 1 GENERAL INFORMATION 1-1

1.1 PURPOSE 1-1
1.2 ORGANIZATION 1-1
1.3 USE 1-1
1.4 RESPONSIBILITIES 1-2
1.5 SUBMITTALS 1-3
1.5.1 Deliverables for Review 1-3
1.5.1.1 Overview 1-3
1.5.1.2 Schematic Design 1-4
1.5.1.3 Design Development 1-4
1.5.1.4 75% Contract Documents 1-5
1.5.1.5 95% Contract Documents 1-6
1.5.1.6 100% Contract Documents 1-6
1.6 FAA DOCUMENTS 1-6
1.6.1 Federal Aviation Administration Orders 1-7
1.6.2 Federal Aviation Administration Standards 1-7
1.6.3 Federal Aviation Administration technical INSTRUCTION 1-7
1.6.4 Occupational Safety And Health Administration (OSHA) Standards 1-7
1.6.5 Institute of Electrical and Electronics Engineers (IEEE) 1-7

SECTION 2 CPDS DESCRIPTION 2-1

2.1 OVERVIEW 2-2
2.2 SUBSYSTEM DESCRIPTIONS TYPE BASIC 2-3
2.2.1 Engine Generator (GEN) 2-3
2.2.2 Generator Switchboard (GpH) 2-4
2.2.3 Service Switchboard (SESH) 2-4
2.2.4 Automatic Transfer Switch (ATS) 2-4
2.2.5 Essential Switchboard (EPH) 2-4
2.2.6 Essential Distribution Panel (EDPH, EDPH-CAB) 2-5
2.2.7 Uninterruptible Power System (UPS) 2-5
2.2.8 UPS Output Panelboard (UpH) 2-5
2.2.9 Essential & Non-essential 208V Distribution Panel (EPHM) 2-6
2.2.10 Primary Transformer Disconnect (D-STS-CAB-A, D-STS-CAB-B) 2-6
2.2.11 Critical & Essential Transformers (T-EDPL, t-STS-A, & T-STS-B, T-EDPH2-CAB, T-EDPL-CAB, T-STS-CAB-A, & T-STS-CAB-B) 2-6

2.2.12 Essential & Non-essential 208V Distribution Panels (EDPL, EDPL-CAB) 2-6
2.2.13 Essential 480/277V Distribution Panels (EDPH2-CAB) 2-6
2.2.14 essential Panels (EPL, EPL-CAB) 2-6
2.2.15 Static Transfer Switchs (STS, STS-CAB) 2-7
2.2.16 Critical Distribution Panels (CDPL, CDPL-CAB) 2-7
2.2.17 Critical Panels (CPL, CPL-CAB) 2-7
2.2.18 Load Bank 2-8

2.3 RELATIONSHIP OF UNITS 2-9

SECTION 3 DESIGN IMPLEMENTATION REQUIREMENTS 3-1

3.1 CODES AND STANDARDS 3-1

3.2 DRAWING INFORMATION 3-1
3.2.1 Grounding 3-1
3.2.2 Seismic Considerations 3-1
3.2.3 Equipment Layout and Space Allocation 3-1
3.2.4 Transient Voltage Surge Suppression .... **Error! Bookmark not defined.**

3.3 FACILITY LOADS 3-2
3.3.1 Critical Loads 3-2
3.3.2 Essential Loads 3-2

3.4 EQUIPMENT SIZING 3-2
3.4.1 Utility Transformer Sizing 3-3
3.4.2 UPS Sizing 3-3
3.4.3 Generator Sizing 3-3
3.4.4 Load Bank Sizing 3-3

3.5 SUBSYSTEM QUANTITIES 3-3

3.6 GENERAL CPDS DESIGN CRITERIA 3-3
3.6.1 Breaker Quantities and Sizes 3-3
3.6.2 Feeder Circuit Sizing and Location 3-3
3.6.3 Breaker Trip Settings 3-4
3.6.4 Switchboard or Distribution Panels 3-4
3.6.5 Load Evaluation and Demand Factors 3-4
3.6.6 Equipment Physical Data 3-4

3.7 STUDY REQUIREMENTS AND ASSUMPTIONS 3-4
3.7.1 General 3-5
3.7.2 Software Application for Study Calculations 3-5
3.7.3 Source of Data 3-5
3.7.4 Protective Devices 3-5

Appendix A —Acronyms and Abbreviations 1

Appendix B —Report Template for Studies 1

Appendix C —Manufacturer's Documentation 1

C.1 TBD GenerATOR Equipment 1
Generator 1
Automatic Transfer Switch 1
C.2 EATON Equipment 1
Uninterruptible Power Supply 1
C.3 L–3 Equipment 1
Static Transfer Switch 1
C.4 Square D Equipment 1
Switchboards 1
Panelboards 1
I-Line panelboards 1
C.4 RAYVOSS Equipment 1
SURGE PROTECTION DEVICES 1

Appendix D —Construction Specifications 1

Appendix E —Drawings 1

E 1 Drawing List 1

SECTION 1 GENERAL INFORMATION

These Design Guidelines were developed to facilitate incorporation of the Type Basic Critical Power Distribution System (CPDS) into new and renovated National Air Space (NAS) Level 9-10 Air Traffic Control Towers (ATCT) and Terminal Radar Approach Control (TRACON) facilities as based upon terminal manager input (ATO-T). The Type CPDS meets reliability, maintainability, and coordination requirements regarding critical power distribution for these facilities.

1.1 PURPOSE

The purpose of these Design Guidelines is to provide the Design Engineer with design information required to incorporate the Type Basic CPDS into their facility design.

1.2 ORGANIZATION

These guidelines are organized to facilitate the site implementation of the CPDS by the Design Engineer, as follows:

Section 1 – Provides information regarding this document; the expected responsibilities of the Design Engineer, Service Area, and Power Services Group (PSG); and the applicable FAA standards.

Section 2 – Provides a description of the Type Basic and Basic CAB CPDS.

Section 3 – Provides the requirements for implementing the Type Basic and Basic CAB CPDS at the intended site.

Appendix A – Provides a list of acronyms and abbreviations used within this document.

Appendix B – Provides a report template for the Short Circuit, Load Flow, and Protective Device Coordination studies. Guidelines for updating the report template are also provided. The sample provided is in Paladin DesignBase (formerly EDSA) the FAA preferred software for such.

Appendix C – Provides manufacturer's documentation related to electrical equipment.

Appendix D – Provides generic construction specifications for installation of electrical equipment and installation requirements.

Appendix E – Provides electrical drawings for design criteria.

Appendix F – Provides equipment time table and scheduling.

1.3 USE

The Design Engineer shall utilize the information contained in this document to perform the following tasks:

- Evaluate the facility loads to:
    - Size utility transformers.

    - Size certain CPDS equipment such as the essential & UPS output panels, Load Bank, etc.
    - Size interconnecting feeders between CPDS equipment.
    - Determine quantities of CPDS equipment sub-systems, such as the CPLs and EPL's
- Identify connections of building power system loads to their appropriate CPDS equipment power source.
- Allocate space for CPDS equipment within the facility.
- Properly layout CPDS equipment within the facility.
- Develop a Short Circuit (SC) study.
- Develop a Load Flow (LF) study.
- Develop a Protective Device Coordination (PDC) study.

1.4 RESPONSIBILITIES

The FAA Power Services Group (PSG) CPDS Program Office shall provide a copy of this Design Guidelines document to the FAA Service Area or ATO Terminal Facilities group, which will in turn provide the document to the designated Design Engineer.

The Design Engineer shall incorporate the CPDS into the facility design based on the information set forth in this document. All questions regarding the use of this document shall be addressed directly to the CPDS Program Office for disposition.

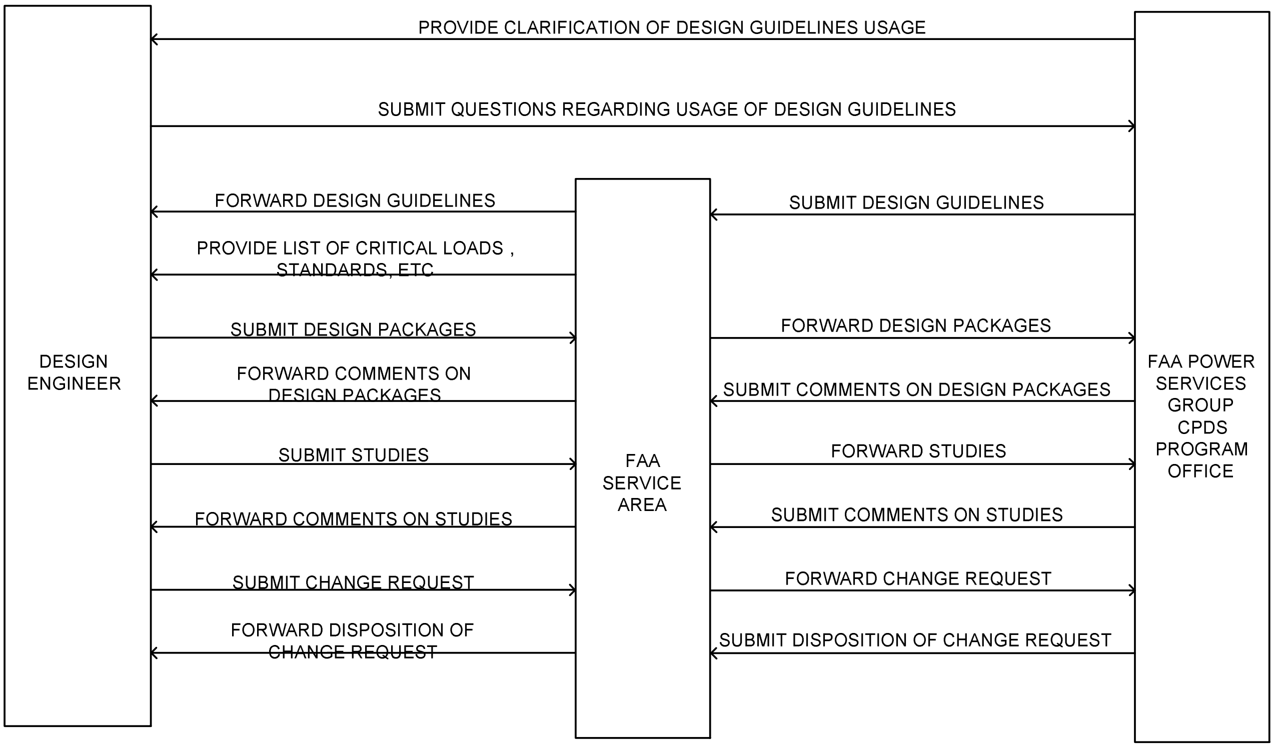
The Service Area or ATO Terminal Facilities group shall provide the Design Engineer with the necessary information to implement the CPDS at the intended site. This information shall include a list of all the facility's critical loads, and a list of applicable standards and requirements not specifically mentioned in this document.

The Design Engineer shall submit the Design Packages in section 1.5.1 to the responsible Service Area. This office shall forward the electrical portion of the Design Package to the CPDS Program Office for review and validation against the Type Basic CPDS design. Comments generated by the CPDS Program Office shall be submitted to the Service Area, who shall forward them to the Design Engineer for disposition. If the CPDS Program Office determines the need, a meeting shall be arranged with the Design Engineer to discuss incorporation of the CPDS into the facility design.

The Design Engineer shall submit the Short Circuit, Load Flow, and the Protective Device Coordination studies to the Service Area. This office shall forward the studies to the CPDS Program Office for review and validation against the Type Basic CPDS design. Comments generated by the CPDS Program Office shall be submitted to the Service Area, who shall forward them to the Design Engineer for disposition.

Any requested changes to CPDS equipment configuration by the Design Engineer shall be submitted through the Service Area, who shall pass them to the CPDS Program Office for review. The CPDS Program Office shall coordinate disposition of the change requests with Service Area and the Design Engineer.

Figure below provides a graphic representation of the information flow described above. Note: It is not the purpose or intention of this document to manage the interface between the Service Area and the Design Engineer, only to specify the information exchange necessary to support efficient implementation of the CPDS at the facility.



Information Flow and Responsibilities

1.5 SUBMITTALS

In addition to the Design Packages, the Design Engineer shall submit the Load Flow and Voltage Drop study, and the Short Circuit and Coordination study. The Load Flow and Voltage Drop study shall verify proper equipment loading and voltage drop at each piece of equipment. The Short Circuit and Coordination study shall verify the withstand rating for each piece of equipment and include coordination curves with text descriptions, as well as a circuit breaker settings table. The CPDS Program Office shall review the Design Package to verify proper integration of the Type Basic CPDS into the facility design.

1.5.1 DELIVERABLES FOR REVIEW

1.5.1.1 OVERVIEW

The Power Services Office has outlined the following deliverables that shall be reviewed for compliance with the standard design. It is important that each deliverable contains the appropriate level of information requested.

1.5.1.2 SCHEMATIC DESIGN

The Schematic Design deliverable shall indicate 20% completion, and shall consist of the following information:

- A single line diagram with equipment names, but not sizes, indicated,
- Floor plans with room size allocations. This shall show the compartmentalization of rooms with room names taken from the standard power design,
- An acknowledgment letter indicating that the professional engineer is following the current standard with all modifications and revisions. Refer to Appendix A, Engineering Acknowledgement, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A load calculation that identifies the critical, essential, and non-essential loads as well as assumptions regarding demand factors and diversity. Refer to Appendix B, Load Calculations, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information, and
- A Schedule of the future deliverables.

Upon receipt of a deliverable, the Power Services Office shall return comments within 10 business days using overnight delivery. If a conference call is requested by either the Consulting Firm or Power Services Office, it shall occur within 10 business days of the request date.

1.5.1.3 DESIGN DEVELOPMENT

The Design Development deliverable shall indicate 40% completion, and shall consist of the following information:

- A 100% complete single line diagram with equipment names and sizes,
- Floor plans with equipment locations. This shall show the compartmentalization of rooms and equipment with room names taken from the standard power design,
- System block diagrams for ancillary systems including fuel oil, fire alarm, and power monitoring systems,
- An acknowledgment letter indicating that the professional engineer is following the current standard with all modifications and revisions. Refer to Appendix A, Engineering Acknowledgement, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A load calculation that identifies the critical, essential, and non-essential loads as well as assumptions regarding demand factors and diversity. Refer to Appendix B, Load Calculations, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A cost estimate with Government Furnished Equipment (GFE) information, and
- A schedule of the future deliverables.

Upon receipt of a deliverable, the Power Services Office shall return comments within 10 business days using overnight delivery. If a conference call is requested by either the consulting firm or Power Services Office, it shall occur within 10 business days of the request date.

1.5.1.4 75% CONTRACT DOCUMENTS

The 75% Contract Documents deliverable, which shall indicate an overall 75% completion, consists of the following information:

- 100% complete single line diagram with equipment names and sizes,
- 75% complete floor plans with equipment locations. This shall show the compartmentalization of rooms and equipment with room names taken from the standard power design,
- Fully developed system block diagrams for ancillary systems including fuel oil, fire alarm, power monitoring systems, and emergency power off systems,
- An acknowledgment letter indicating that the professional engineer is following the current standard with all modifications/revisions. Refer to Appendix A, Engineering Acknowledgement, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A load calculation that identifies the critical, essential, and non-essential loads and all assumptions regarding demand factors and diversity. Refer to Appendix B, Load Calculations, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A cost estimate with GFE information,
- Details of installation along with book specifications,
- An inventory of GFE, including contract numbers and CLIN designations, prior to requisition, and
- A schedule of the future deliverables.

Upon receipt of a deliverable, the Power Services Office shall return comments within 10 business days using overnight delivery. If a conference call is requested by either the consulting firm or Power Services Office, it shall occur within 10 business days of the request date.

1.5.1.5 95% CONTRACT DOCUMENTS

The 95% Contract Documents deliverable, which shall indicate an overall 100% completion, consists of the following information:

- 100% complete single line diagram with equipment names and sizes,
- 100% complete floor plans with equipment locations. This shall show the compartmentalization of rooms and equipment with room names taken from the standard power design.
- Fully developed diagrams for ancillary systems including fuel oil, fire alarm, power monitoring systems, and emergency power off systems.
- An acknowledgment letter indicating that the professional engineer is following the current standard with all modifications/revisions. Refer to Appendix A, Engineering Acknowledgement, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A load calculation that identifies the critical, essential, and non-essential loads and all assumptions regarding demand factors and diversity. Refer to Appendix B, Load Calculations, in Volume 10, Part 1, Book 1 of TI6480.3, CPDS for additional information,
- A cost estimate with GFE information,
- Details of installation along with book specifications,
- An inventory of GFE, including contract numbers and CLIN designations, prior to requisition, and
- A schedule of the future deliverables.

Upon receipt of a deliverable, the Power Services Office shall return comments within 10 business days using overnight delivery. If a conference call is requested by either the consulting firm or Power Services Office, it shall occur within 10 business days of the request date.

1.5.1.6 100% CONTRACT DOCUMENTS

The 100% Contract Documents deliverable, which shall indicate an overall 100% completion plus all comments, consists of the following information:

- An acknowledgment letter indicating that all 95% document comments have been incorporated.
- All documents above from 95% submission have been updated & resubmitted with all comments addressed and incorporated.

1.6 FAA DOCUMENTS

The Design Engineer shall adhere to the standards and requirements specified in the FAA documents listed below. This Design Guideline takes precedence in the event of any conflicts with the referenced documents. In the event of any confusion, the Design Engineer shall contact the CPDS Program Office for clarification.

1.6.1 FEDERAL AVIATION ADMINISTRATION ORDERS

6480.3	CPDS Technical Instruction Manuals/Electrical Drawings.
6480.7D	Airport Traffic Control Tower and Terminal Radar Approach Control Facility Design Guidelines, Revision 8/11/04.
6950.27	Short Circuit Analysis and Protective Device Coordination Study.

1.6.2 FEDERAL AVIATION ADMINISTRATION STANDARDS

FAA-STD-019E	Lightning Protection, Grounding, Bonding, and Shielding
FAA-STD-032	Design Standards For National Airspace System (NAS) Physical Facilities
FAA-C-1217F	Electrical Work, Interior

1.6.3 FEDERAL AVIATION ADMINISTRATION TECHNICAL INSTRUCTION

TI 6480.3	Technical Instruction Book Volume 10: Site Procurement Guide and Interface Requirements (IRD), Part 1: Type 1 CPDS IRD, Book 1: Type 1 CPDS Interface Requirements Document

1.6.4 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) STANDARDS

OSHA CFR 29	Part 1910	Occupational Safety and Health Standards

1.6.5 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 241-1999	IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book)
IEEE 242-1986	IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
IEEE 399-1997	IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (IEEE Brown Book)
IEEE 446-1995	IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book)
IEEE 493 1997	IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)

IEEE books can be obtained from www.ieee.org.

This document is available on CD from the CPDS Program office. If a document is not included on this CD, refer to **www.FAA.gov**. In addition the content of all PSG CAD drawings are provided in AutoCAD 2005, for editing and use by the Design Engineer in preparing the facility design. A sample of the CPDS Short Circuit, Load Flow and Protection Device Coordination Study in Paladin DesignBase (formerly EDSA) shall be provided. It is not specific to this facility. The Engineer performing these studies for the specific facility shall build the complete model for the facility power system by incorporating actual equipment sizes, cable sizes and length, and utility fault contributions and transformer impedances.

SECTION 2 CPDS DESCRIPTION

The CPDS is a collection of tightly integrated subsystems, which are themselves comprised of commercial-off-the-shelf (COTS) items. When perusing the information provided below, the reader is encouraged to refer to the CPDS Type Basic One-Line diagram for clarity.

Subsystem Name	Designations	Quantity
Engine Generator with load bank	GEN with LBHG	1
Generator Panel with SPD	GPH	1
Service Switchboard with SPD	SESH	1
Automatic Transfer Switch	ATS	1
Essential Panel with SPD	EPH	1
Essential Distribution Panels	EDPH	1
Uninterruptible Power System	UPS	1
UPS Maintenance Bypass Panel	EPHM	1
UPS Output Panel with SPD	UPH	1
Essential Primary Transformer Disconnects (Optional)	D-EDPL, D-STS-A, D-STS-B	3
Critical, Essential & Secondary Transformers	T-EDPL, T-STS-A, T-STS-B,	3
Essential 208V Distribution Panels	EDPL	1
Static Transfer Switch	STS	2*
Critical 208V Distribution Panels	CDPL	1
Essential Panels with SPD	EPL1, EPL2	2*
Critical Panels with SPD	CPL1, CPL2	2*
Load Bank for UPS	LBHU	1

Subsystem Designations for Basic - * Quantity will vary

Subsystem Name	Designations	Quantity
Essential Distribution Panels	EDPH1-CAB	1
Optional Essential Primary Transformer Disconnects	D-EDPL-CAB, D-EDPH2-CAB	2
Critical Primary Transformer Disconnects	D-STS-CAB-A. D-STS-CAB-B	2
Static Transfer Switch	STS-CAB	1*
Critical, Essential & Secondary Transformers	T-EDPH2-CAB, T-EDPL-CAB, T-STS-CAB-A, T-STS-CAB-B,	4
Essential 480/277V Distribution Panel	EDPH2-CAB	1
Essential 208V Distribution Panels	EDPL-CAB	1
Critical Distribution Panels	CDPL-CAB	1*
Essential Panel	EPL1-CAB, EPL2-CAB	2
Critical Panel	,CPL1-CAB, CPL2-CAB	2*

Subsystem Designations for Basic CAB - * Quantity will vary

2.1 OVERVIEW

The CPDS Type Basic utilizes a single utility feeder, standby Engine Generator (GEN), essential distribution panel (EPH), Uninterruptible Power System (UPS), and Static Transfer Switches (STSs), etc to manage power for the facility's critical, essential, and non-essential loads. This allows for rapid diagnosis of the system and facilitates maintenance and troubleshooting.

The CPDS Type Basic is considered to be in a normal configuration when the utility feeder is on line and providing power within specifications, the essential panel is active, all circuit breakers and components are in the normal positions, and the generator is available. In this configuration, the essential panel (EPH) is powered independently by an associated utility service switchboard SESH and the generator panel GPH via an Automatic Transfer Switch (ATS).

The CPDS Type Basic incorporates one essential panel and one redundant source (1 utility & 1 generator) to maintain power to critical, essential, and non-essential loads.

The utility feeds essential loads through service switchboard (SESH) and Essential Panel (EPH), which only EPH is powered by a generator source thru Automatic Transfer Switch ATS. If the utility source is lost, the ATS will send a start signal to the generator to come online. Once online, the generator will carry only the loads connected to EPH not SESH. SESH feeds some essential and optional non essential loads in the base building and tower but also is the alternate feeder for both Static Transfer Switches (1 in base and 1 in tower).

For other essential loads (mechanical, lighting, receptacles, etc), this equipment is fed from Essential Distribution Panel (EDPH). If a utility outage occurs, the loads will be re-powered once the generator has started and comes online.

The CPDS Type Basic supplies critical loads with filtered and continuous power through an Uninterruptible Power System (UPS). The critical load is supplied by the UPS via the UPS Output Panel (UPH), the Static Transfer Switches (STS, STS-CAB), Critical Distribution Panels (CDPL, CDPL-CAB) and one or more Critical Power Panels (CPLs, CPL-Cabs).

To provide continuous power to critical loads, the UPS uses either its normal, battery, or bypass power to supply the UPS output panel (UPH). If any one source is lost, the UPS can switch to battery with no loss of power to the critical loads. The 480V UPS output (UPH) feeds the Static Transfer Switchs via step down transformers. The Static Transfer Switch then feeds the 208Y/120V Critical Distribution Panels (CDPL. CDPL-CAB) which then feed multiple CPL's and CPL-CABs as required.

Each critical panel (CPL, CPL-CAB) is fed by a STS thru the CDPL or CDPL-CAB. The STS primary source is UPH and alternate source is EPHM. Like the UPS, the STS are designed to ensure continuous power to the CPLs. If the primary source fails, the alternate source will transfer within 4 ms to keep continuous power to the critical load. If a STS is taken out for service, the critical loads fed by that STS will be dropped.

2.2 SUBSYSTEM DESCRIPTIONS TYPE BASIC

The sections below describe the intended use and capabilities of the various subsystems as they apply to the overall CPDS. A description of the major equipment comprising each subsystem is included. The descriptions are applicable to any site based on the CPDS Type Basic. The specific volumes of the technical instruction book containing detailed information are also referenced in the sections below. All external hardware and electrical interface characteristics associated with the FAA use of the CPDS are included.

Most equipment located on E440 is backed up by generator. Designer shall verify which loads are connected to which panels. If generator back up is required, connect loads to panels that are backed up by generator. The generator is located in the base building.

2.2.1 ENGINE GENERATOR (GEN)

The Type Basic CPDS implements one generator to ensure standby power is available to essential switchboard in the event of a utility outage. The generator sizes indicated on drawings are a typical range of sizes but the designer should determine the generator size based on the loads it is required to protect. The generator shall be sized to handle the required loads that need generator back up in the CPDS design. When the CPDS is in a normal configuration, the generator is shut down, but is ready to start when required.

In the event of a utility outage, the ATS automatically sends a signal starts the generator. Once the generator reaches its rated voltage and frequency, the ATS will transfer the load to the generator.

The generator is supplied with a load bank sized to match the generator as well as a daytank when applicable..

2.2.2 GENERATOR SWITCHBOARD (GPH)

There is one generator panel that is fed by the single generator. The GPH is constructed using I Line distribution panel enclosures with an externaly mounted surge protection device (SPD). GPH typically has 3 separate sections. The first section is used to feed the fire pump. The second section feeds the generator All other circuits are fed from the third section including the ATS. When there is a loss of utility service, the ATS starts the generator and the generator switchboard feeds the loads connected to it but not the entire building.

2.2.3 SERVICE SWITCHBOARD (SESH)

There is one main utility service switchboard that is fed from one single incoming utility feeder. The SESH is typically constructed using Power Style QED 2 with an externally mounted surge protection device (SPD). The service switchboard feeds the essential loads (EPH), optional non essential loads (NPH) in the base building and tower, and the secondary side of the STSs in the base building and cab via panels EPHM. The fire pump is fed either from a tap off the utillty feeder, or a second section in SESH containing no other circuits.

2.2.4 AUTOMATIC TRANSFER SWITCH (ATS)

There is a single automatic transfer switch that is fed from the service switchboard and from the single generator panelboard. There is a single incoming utility feeder. If the utility feeder eexperiences an outage or becomes out of tolerance, the ATS will transfer to the generator panelboard.

2.2.5 ESSENTIAL SWITCHBOARD (EPH)

The CPDS Type Basic implements one EPH to distribute power from the utility service and generator service, if required. The EPH distributes power to most of the equipment in the building; critical, essential and optional non-essential. The EPH typically utilizes I Line distribution panel enclosures with an externally mounted surge protection device (SPD). .

In a normal configuration, the panelboard is fed from SESH. In the event of a utility outage, the ATS starts the generator and EPH bus is fed by generator when it reaches the required speed and voltage.

2.2.6 ESSENTIAL DISTRIBUTION PANEL (EDPH, EDPH-CAB)

The CPDS utilizes one EDPH and EDPH-CAB to distribute power to essential mechanical equipment, receptacles, lights, and other miscellaneous loads. They both utilize I-Line type distribution panel construction. Normal input power is received through the essential panelboard (EPH).

2.2.7 UNINTERRUPTIBLE POWER SYSTEM (UPS)

The CPDS implements a single UPS to provide “clean” filtered continuous power from the utility or generator source to all critical loads. The single module UPS consists of a stand alone UPS module with sealed VRLA or wet cell batteries. The UPS size should be determined based on the critical loads it is required to protect by the designer. Typically VLRA batteries are located in the same room as the UPS module. Flooded wet cell batteries are typically located in a separate room as the the UPS module. The DC battery cables shall be sized to limit to voltage drop to 2V at 480V DC. The Power Services Group (PSG) prefers wet cell batteries. Wet cell batteries are more reliable, but if space does not allow for wet cells, use sealed VRLA. The UPS is sized to accommodate all critical loads only in the CPDS.

The UPS receives normal input power from EPH. Bypass input power and UPS maintenance wrap is also supplied by EPH. If the UPS is down for maintenance, the maintenance bypass feature can be utilized in conjunction with the STS to keep the critical loads unaffected.

The UPS has three modes of operation: normal, battery, and static bypass. The UPS automatically switches between these modes as required during system operation. When the UPS is in normal mode, normal AC input power is converted to DC by a rectifier. This allows a trickle charge of the batteries, so that they are always fully charged when needed. The DC power is then converted back to AC by an inverter. If the normal AC input is lost, the UPS switches to battery mode with no interruption of power to the critical loads. In this mode, DC power flows from the batteries and through the inverter, which converts it to AC. The UPS remains in battery mode until normal input power is returned or the DC voltage drops too low to support the inverter. If both the normal input and the batteries are unavailable, the UPS switches to static bypass mode. The UPS uses a static switch to maintain continuous power to the critical loads as the necessary contacts open or close to route power from the bypass input source to the loads. While in bypass mode, the UPS provides “dirty” unfiltered power to the critical loads.

2.2.8 UPS OUTPUT PANELBOARD (UPH)

The CPDS implements one UPH panelboard to distribute power from the UPS to the critical loads via static transfer switch. UPH utilizes I-Line distribution panel enclosures with an externally mounted surge protection device (SPD). UPH has two alternate feeds. One feed from GPH, and another directly from EPH. The feed from GPH would be utilized to bypass the ATS and EPH to allow for maintenance on those components while maintaining an alternate source to the STS. The feed directly from EPH would be used when maintenance of the UPS is required.

The UPH also feeds critical loads in the tower via STS-CAB.

2.2.9 ESSENTIAL & NON-ESSENTIAL 208V DISTRIBUTION PANEL (EPHM)

The CPDS implements one EPHM to provide power from the SESH switchboard, and the GPH panelboard to the critical loads to the downstream STS. The panel is constructed using the I-Line distribution panel enclosures. EPHM feeds the alternate side of the static switch so if the UPS is down for maintenance then the alternate side can be fed from utility service or generator backup.

2.2.10 PRIMARY TRANSFORMER DISCONNECT (D-STS-CAB-A, D-STS-CAB-B)

The CPDS implements one D-STS-CAB-A, and one D-STS-CAB-B to protect the primary side of transformer T-STS-CAB-A, and T-STS-CAB-B. Location of this disconnect shall be field located by the Design Engineer. Disconnects are a 480V fused disconnects using NEMA 1 construction. D-STS-CAB-A is fed from UPH. D-STS-CAB-B is fed from EPHM.

The disconnects protect the primary side of transformer and also is used in case of maintenance on transformer. These disconnects are located next to transformer.

2.2.11 CRITICAL & ESSENTIAL TRANSFORMERS (T-EDPL, T-STS-A, & T-STS-B, T-EDPH2-CAB, T-EDPL-CAB, T-STS-CAB-A, & T-STS-CAB-B)

The transformers are used to step down the 480V critical and essential power down to 208Y/120V. The transformers are all located near their respective panels. If harmonics is an issue at the site, provide a minimum of a K-13 rated transformer. The transformer T-EDPH2-CAB is 480V-480/277V to feed any 277V loads in the tower.

2.2.12 ESSENTIAL & NON-ESSENTIAL 208V DISTRIBUTION PANELS (EDPL, EDPL-CAB)

The CPDS Type Basic implements one EDPL and EDPL-CAB to distribute power from EPH and EDPH1-CAB to the essential loads. The distribution panels are constructed using the I-Line distribution panel enclosures. EDPL is fed from EPH, and EDPL-CAB from EDPH1-CAB via 480V-208Y/120V step down transformers.

2.2.13 ESSENTIAL 480/277V DISTRIBUTION PANELS (EDPH2-CAB)

The Type Basic CAB CPDS utilizes one EDPH2-CAB to distribute power to all 277V loads which might include mechanical equipment, lights, and other non-essential loads located in the tower. The EDPH2 utilizes I-Line type distribution panel construction. Normal input power is received from essential switchboard EPH located in the base building.

2.2.14 ESSENTIAL PANELS (EPL, EPL-CAB)

The CPDS Type Basic implements a minimum of two EPLs an EPL-CABs to distribute power from EPH for essential loads. The EPLs are fed from EDPL and EPL-CABs are fed from EDPL-CAB. All panels are built as panelboard construction with only one main breaker (not dual main circuit breaker option like other CPDS designs) and an externally mounted surge protection device (SPD) device.

2.2.15 STATIC TRANSFER SWITCHS (STS, STS-CAB)

The CPDS Type Basic implements one STS and STS-CAB to distribute continuous, filtered power from the UPS (generator backed) and raw utility power directly from SESH (no generator backup). The STS feeds critical panels (CPLs, CPL-CABs) via one CDPL and CDPL-CAB. The STS shall be dispersed through-out the critical facility as required. The STS is a 3-phase, two-position switching device which automatically transfers a load between two power sources, designated Primary and Alternate within 4 ms. A Programmable Logic Controller (PLC) is built into the STS to control the power transfer.

A STS has two modes of operation: static and bypass. The STS is normally in the static mode, while the bypass mode is only used in the extreme situation that the STS itself is damaged. When in the static mode, the power from both sources is routed to the Silicon Controlled Rectifier (SCR) module. The selected source passes through the SCR, while the other source is halted. If the PLC orders a transfer to the other source, the SCR performs the transfer without causing a significant loss of power. The transfer time between power sources is within 4 milliseconds as specified by equipment manufacturer. Considering the impact on the critical loads, this small transfer time is short enough to be deemed continuous. When in the bypass mode, the SCR is circumvented, so a transfer causes a loss of power to the critical loads. The bypass mode is provided as a redundancy in the event that the SCR becomes unusable.

The STS is associated with UPH and EPHM and each one receives primary power from UPH and alternate power from EPHM. The STS and STS-CAB provide power to the CPLs and CPL-CABs via a CDPL and CDPL-CAB.

Note that the grounding electrode of T-STS-A,T-STS-B, T-STS-CAB-A and T-STS-CAB-B must be tied together as indicated on drawings since the static transfer switches are 4 pole.

2.2.16 CRITICAL DISTRIBUTION PANELS (CDPL, CDPL-CAB)

The CPDS Type Basic implements one CDPL and CPDL-CAB to distribute power from the automatic static transfer switch to multiple critical panels to feed the critical loads. Generally, the critical panels are not fully utilized but breaker pole spaces are used up so these distribution panels allow additional critical panels to be added as required. The distribution panels are constructed using the I-Line distribution panel enclosures. They are fed via a 208V automatic Static Transfer Switch (STS, STS-CAB).

2.2.17 CRITICAL PANELS (CPL, CPL-CAB)

The CPDS Type Basic implements two CPLs and CPL-CABs to distribute power from the STS and STS-CAB for critical loads. The CPLs are normally fed from the UPS. All panels are built as panelboard construction with only one main breaker (not dual main circuit breaker option like other CPDS designs) and an externally mounted surge protection device (SPD) device. The CPL panels are fed from the STS via CDPL and the CPL-CAB panels are fed from STS-CAB via t CDPL-CAB.

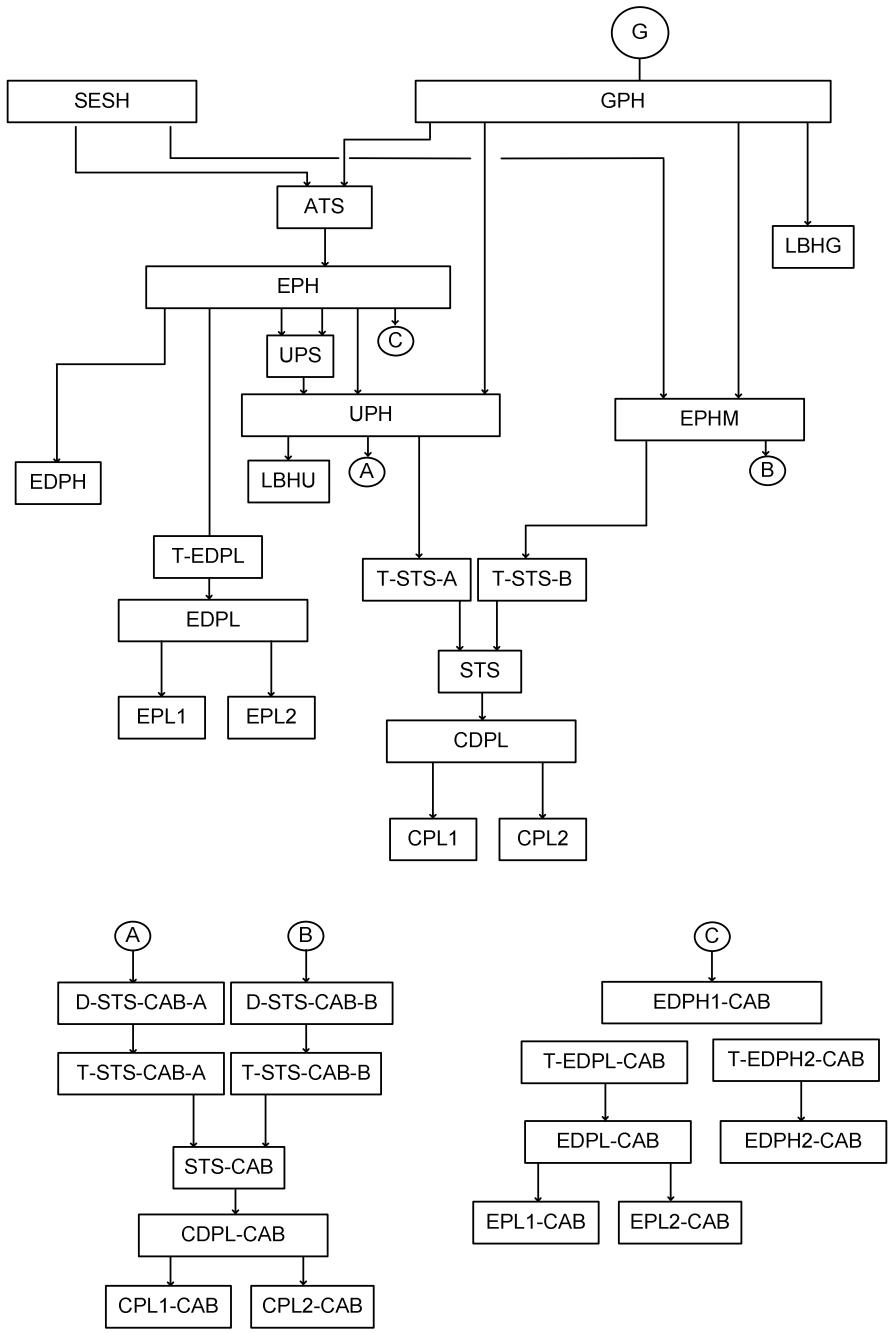
2.2.18 LOAD BANK

The CPDS Type Basic implements one load bank for the UPS and one load bank for the generator. Each load bank is supplied with a remote load bank control panel. The generator load bank can also be used to prevent under loading of the generator by adding a resistive load to the total facility load, when necessary. The load bank resistors generate a large amount of heat, so a safety interlock ensures that the cooling blower is running before a load is applied.

Each Load Bank Control Panel allows load to be typically applied in increments as low as 5kW to maximum size of the load bank. The load banks will be sized to match its respective generator and UPS. The control panels are normally in local mode and are located next to the equipment that it is load testing.

2.3 RELATIONSHIP OF UNITS

A block diagram representing the Type Basic and Basic CAB CPDS subsystems is shown in the Figure below. The equipment is identified by their respective designations. The illustration depicts the subsystems, the basic interconnections between units, and their relationship with other equipment.



Relationship of Units

SECTION 3 DESIGN IMPLEMENTATION REQUIREMENTS

This section provides the requirements for effective implementation of the CPDS Type Basic at the intended site. Designer shall refer to TI 6480.3, Interface Requirement Document (IRD) for additional information and requirements for all equipment sizing.

3.1 CODES AND STANDARDS

The Design Engineer shall be familiar with the FAA documents that regulate the CPDS implementation, as listed in Section 1.6 and as specified by the Service Area. The Design Engineer is also responsible for ensuring that the Facility and the CPDS are designed in accordance with all applicable local codes.

3.2 DRAWING INFORMATION

The Design Engineer shall be familiar with the design information contained in the Type Basic and Basic CAB CPDS engineering drawings. This information is briefly described in the sections below.

The CPDS Type Basic One-Line diagrams are provided in drawing E440 , which contains all the components of the system to be incorporated into the facility design. It is noted that the 480V distribution portion of the CPDS is 3 wire except there is one panelboard in the tower that is 4 wire. The Design Engineer shall add isolation transformers as needed to serve 480Y/277V, 4 wire loads in the base building and step down transformers for miscellaneous 208Y/120V loads.

The reference drawings shall be reviewed by Design Engineer to incorporate all design aspects and adapted to each site as applicable. These reference drawings shall be used by the design engineer to develop equipment layouts, grounding, signage, fuel systems, etc.

3.2.1 GROUNDING

The Design Engineer shall employ standard IEEE practices for the grounding design of CPDS equipment in coordination with FAA STD-019e.

3.2.2 SEISMIC CONSIDERATIONS

Anchoring and raceway bracing to meet the seismic zone that the facility is located shall be determined by its location. All seismic details shall be approved by a licensed structural engineer.

3.2.3 EQUIPMENT LAYOUT AND SPACE ALLOCATION

CPDS equipment shall be laid out in the facility and equipment rooms assigned by FAA in coordination with recommended layout and spacing requirements shown on Type 1 Basic drawing E200, which is used for reference only. The layout shown on E110LS is a guide only and exact dimensions required shall be validated by the design engineer. The equipment shall be located to minimize voltage drops. The Design

Engineer shall use good engineering practice, manufacturer's shop drawings and recommendations to properly layout equipment.

3.2.4 SURGE PROTECTIVE DEVICES (SPD)

The designer shall perform a transient analysis to evaluate the location of additional SPD devices throughout system. Currently, SPD devices are located on the main incoming service switchboard and all CPL and UPL panelboards. These are minimum requirements. Due to facility layout, SPD devices could also be located on the UPS input and output switchboards. Designer shall coordinate all locations with FAA.

3.3 FACILITY LOADS

The sections provided below describe the requirements for implementing critical, essential, and non-essential loads within the facility.

3.3.1 CRITICAL LOADS

All electronic loads that the FAA has certified as critical shall be connected to the critical power system. The Service Area will provide the Design Engineer with a list of all the facility's critical loads. Refer to FAA Order 6480.7C for additional information on critical loads.

Critical branch circuit power panels shall be rated as 225A, 208Y/120V, 10KAIC, main breaker, forty two or eighty four 20A-1-pole bolt-on breakers. Critical branch circuit panels shall be connected to STSs via CDPLs as shown on the CPDS Type Basic and One-Line diagram.

Each critical load shall be connected to the nearest panel to compensate for voltage drop and shall be properly balanced.

3.3.2 ESSENTIAL LOADS

All feeders as shown on the CPDS One-Line diagrams shall serve essential loads. All essential loads shall be supported by one generator, without load shedding. Refer to FAA STD 6480.7C for additional information on essential loads.

Essential branch circuit power panels shall be rated a minimum of 225A, 208Y/120V, 10KAIC, main breaker, and bolt-on branch breakers. Panels shall connect to the appropriate power source as shown on the CPDS Type Basic One Line diagram. Each essential load shall be connected to the nearest panel to compensate for voltage drop and shall be properly balanced.

3.4 EQUIPMENT SIZING

The CPDS Type Basic One-Line diagram shows the maximum number of CPDS sub-systems (Essential & Critical Panels, STSs, etc) are also shown on the CPDS One-Line diagram.

3.4.1 UTILITY TRANSFORMER SIZING

The utility transformer shall be sized using the demand factors given in CPDS Load Evaluation and Demand Factors section of this document.

3.4.2 UPS SIZING

Once the Service Area provides a listing of all critical equipment to be connected to the critical power system, the UPS shall be sized to support this load at a 100% demand factor. Each UPS unit shall be of sufficient size to enable it to independently carry the total critical load requirements for the facility. The maximum load the UPS should be designed around is 90% red-line.

3.4.3 GENERATOR SIZING

Generator shall be sized to carry the facility's combined essential and critical loads as required. The generator shall not be sized to carry certain non-essential loads in base building and tower. Designer shall coordinate exact loads with FAA that should be on generator power. The generator shall be sized based on load analysis using the mechanical and electrical demand factors provided in Section 3.6.5 of this document.

3.4.4 LOAD BANK SIZING

The Load Banks for the generator and UPS shall be sized to match the generator and UPS rating respectively.

3.5 SUBSYSTEM QUANTITIES

The Design Engineer shall determine the appropriate quantity of HVAC equipment and critical and essential panels as required to accommodate the necessary loads at the facility. The current one line diagrams do not indicate any HVAC requirements. The minimum quantities of each electrical subsystem are shown section 2 and/or the CPDS One-Line diagrams.

3.6 GENERAL CPDS DESIGN CRITERIA

3.6.1 BREAKER QUANTITIES AND SIZES

The minimum quantity of the breakers are indicated on the single line diagrams. The Design Engineer must allocate each load to the appropriate breaker. If additional breakers are needed for other loads, add breakers as required to accommodate additional loading. For I-Line Power Pact and QED 2 style breakers, see Sq D shop drawings for additional information.

3.6.2 FEEDER CIRCUIT SIZING AND LOCATION

Feeder circuits between CPDS equipment shall be sized according to the NEC version specified by the Service Area. Where possible, raceways between government furnished equipment shall be located under slab.

3.6.3 BREAKER TRIP SETTINGS

Adjustable circuit breakers shall be set to coordinate with the characteristics of the load served, and also with upstream/downstream devices, where attainable. Refer to Section 3.7.4 for additional information.

3.6.4 SWITCHBOARD OR DISTRIBUTION PANELS

Designer shall evaluate the use of QED 2 or I Line equipment construction based on available space in the facility. Single line diagrams indicate which type of construction is the preferred method. Designer shall coordinate his requirement with FAA.

3.6.5 LOAD EVALUATION AND DEMAND FACTORS

The Design Engineer shall evaluate the loads connected to branch circuit panels in accordance with NEC. As these panels interface with CPDS equipment, the designer shall again evaluate loads at that level, utilizing demand factors as it works its way up to the switchgear, in order not to oversize the utility transformers and generators.

The following is a brief list of demand factors to be used in load evaluation:

- Mechanical Load Demand Factors
- Worst case season condition – summer
- All air conditioning equipment – 100% demand
- All back-up/redundant equipment – 0% demand
- Elevators – NEC required demand factor based on number of elevators
- Pumps – 50% demand
- Exhaust fans – 100% demand
- All winter heating load – 0% demand
- Electrical Load Demand Factors
- Lighting – 100% demand
- Receptacle – First 10KVA 100% demand, remainder at 50%
- Critical Load – 100% demand (value provided by Service Area)
- Kitchen Load – 50% demand
- Vacuum System – 10% demand

3.6.6 EQUIPMENT PHYSICAL DATA

Physical information (e.g.: size, weight, bus/breaker configuration, maximum cable lug size) of equipment can be found in the manufacturer’s engineering drawings provided in the Appendix.

3.7 STUDY REQUIREMENTS AND ASSUMPTIONS

The Short Circuit, Load Flow, and Protective Device Coordination studies shall be developed in accordance with the information provided in the sections below.

3.7.1 GENERAL

- The Load Flow study, the Short Circuit study, and the Protective Device Coordination study shall be developed using the Paladin DesignBase (formerly EDSA) software application. Samples are provided in the Appendix..
- The Load Flow study shall provide loading with associated voltage drop at various points on the power system, and assure that all of distribution equipment and all circuits have been properly sized to avoid overloading.
- The Short Circuit study and Protective Device Coordination study shall provide the maximum available fault at various points on the power system and verify that each piece of distribution equipment has a sufficient short circuit rating. See Appendix for more information
- The Protective Device Coordination study shall provided circuit breaker settings and demonstrate coordination of all devices in accordance with FAA Order 6950.27.
- The circuit breaker settings shown on the One-Line diagram submitted in the Design Engineer's Final Design Package shall match the settings shown in the Protective Device Coordination study's Circuit Breaker Settings table.

3.7.2 SOFTWARE APPLICATION FOR STUDY CALCULATIONS

Paladin DesignBase (formerly EDSA) Release 2.95 or higher is the only software application accepted by FAA to be used in the Load Flow study, the Short Circuit study, and the Protective Device Coordination study. A sample study is provided..

3.7.3 SOURCE OF DATA

- Engineering Data – Facility load and equipment ratings shall be obtained from design documents.
- Utility Data – The available fault shall be obtained from the local utility on either the primary or the secondary side of the utility transformer. If on the primary side, the utility transformer impedance (Z) and X/R shall also be obtained.
- Installation Data – Cable lengths, sizes, and quantity per phase shall be obtained from site specific design documents provided by Engineer.
- Paladin DesignBase (formerly EDSA) Data – Cable, circuit breaker, fuse, and switch impedance data shall be obtained from EDSA's library.

3.7.4 PROTECTIVE DEVICES

The following information describes the FAA's Philosophy for Setting Protective Devices:

- Series Protective Devices – Protective devices connected in series do not require coordination since the same outage results if any series device opens.

- Main-Tie-Main Breakers – Tie breakers shall be set the same as main breakers (set to overlap). This approach assures that downstream devices coordinate as required by FAA Order 6950.27. Faults generally occur at the load, so the probability of overlapping faults (second order cut-set) in main distribution equipment (i.e.: loss of source to one main and a main bus fault occurring simultaneously) is extremely low.
- Feeder Breakers – Feeder breakers shall be set to coordinate with upstream main protective devices where attainable.
- Transformer Protection – Primary protective devices shall be set to avoid opening upon transformer energization (inrush). Secondary protective devices shall be set to protect transformers against over-currents (down stream overloads and faults).
- Branch Breakers – Non-adjustable branch breakers do not require coordination with upstream protective devices, except on the Critical Circuit. Since the Critical Circuit requires full coordination, the upstream step-down transformer is specified at an impedance value which limits available fault in order to provide branch breaker coordination with upstream feeder/main device. Also, upstream feeder/main devices have been specified at larger frame/sensor sizes to increase instantaneous pickup, which aids in obtaining coordination.
- Hi-Low Fixed Magnetic Breakers – All fixed magnetic breakers with Hi-Low adjustment shall be set to Hi in Paladin DesignBase (formerly EDSA) PDC study cases.

In keeping with IEEE recommendations, the Short Circuit System model should be developed at the earliest possible stage of the design, so that variations in circuit size and length can be implemented efficiently and in a timely manner to correct withstand and coordination problems.

APPENDIX A—ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
A	AMPERE
AA	AMBIENT AIR
AC	ALTERNATING CURRENT
A/C	AIR CONDITIONING
AF	AMPERE FRAME
AI	ANALOG INPUT
AIC	AMPERE INTERUPTING CAPACITY
ALT	ALTERNATE
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
AT	AMPERE TRIP
ATS	AUTOMATIC TRANSFER SWITCH
AUX	AUXILLIARY
AVG	AVERAGE
AWG	AMERICAN WIRE GAUGE
AX	AMPERE RATING PLUG
BATT	BATTERY
BC	BARE COPPER
BD	BUS DUCT
BI	BYPASS INPUT
BKR	BREAKER
BLDG	BUILDING
BP III	BALANCED POWER III
BTU	BRITISH THERMAL UNIT
CAT	CATEGORY
CB	CIRCUIT BREAKER
CCP	CRITICAL CONTROL POWER
CFG	CONFIGURATION
CHG	CHARGER
CM	CIRCUIT MONITOR
COMM	COMMUNICATIONS
COTS	COMMERCIAL OFF THE SHELF
CPDS	CRITICAL POWER DISTRIBUTION SYSTEM
CPL	CRITICAL POWER PANEL
CPT	CONTROL POWER TRANSFORMER
CT	CURRENT TRANSFORMER
CTR	CENTER
CU FT	CUBIC FEET
D	DIGITAL
DB	DECIBEL
DBL	DOUBLE
DC	DIRECT CURRENT

Acronym/Abbreviation	Definition
DI	DIGITAL INPUT
DIA	DIAMETER
DISC	DISCONNECT
DIST	DISTRIBUTION
DPC	CRITICAL DISTRIBUTION PANEL
DPE	ESSENTIAL DISTRIBUTION PANEL
DPN	NON-ESSENTIAL DISTRIBUTION PANEL
DO	DIGITAL OUTPUT
DS	DISCONNECT SWITCH
DWG	DRAWING
EA	EACH
ECMS	ENVIRONMENTAL CONTROL AND MONITORING SYSTEM
EG	ENGINE GENERATOR
ELEC	ELECTRIC
ELEM	ELEMENTARY
ELEV	ELEVATION
EMCC	ESSENTIAL MOTOR CONTROL CENTER
ENCL	ENCLOSURE
EPA	ENVIRONMENTAL PROTECTION AGENCY
EPO	EMERGENCY POWER OFF
EQUIP	EQUIPMENT
EST	ESTIMATE
EXT	EXTERIOR
FA	FORCED AIR
FAA	FEDERAL AVIATION ADMINISTRATION
FDR	FEEDER
FLA	FULL LOAD AMPERES
FT	FEET
FVNR	FULL VOLTAGE NON-REVERSING
FWD	FORWARD
GA	GAUGE
GEN	ENGINE GENERATOR
GFE	GOVERNMENT FURNISHED EQUIPMENT
GFI	GROUND FAULT INTERUPTER
GFM	GOVERNMENT FURNISHED MATERIAL
GND	GROUND
GOVT	GOVERNMENT
HP	HORSEPOWER
HT	HEIGHT
HTR	HEATER
HVAC	HEATING, VENTILATING, AND AIR CONDITIONING
HZ	HERTZ
I/O	INPUT/OUTPUT

Acronym/Abbreviation	Definition
IAW	IN ACCORDANCE WITH
IC	INTEGRATED CIRCUIT
ILS	INTEGRATED LOGISTICS SUPPORT
IN	INCH
INSTR	INSTRUMENT
INT	INTERIOR
JB	JUNCTION BOX
JCT	JUNCTION
KCM	KILO-CIRCULAR MIL
kVA	KILO-VOLTS AMPERE
KW	KILOWATT
L	LENGTH
LAT	LATERAL
LBS	POUND
LDP	LOAD BANK DISTRIBUTION PANEL
LH	LEFT HAND
MAINT	MAINTENANCE
MAX	MAXIMUM
MCC	MOTOR CONTROL CENTER
MCM	MILLI-CIRCULAR MIL
MCS	MOLDED CASE SWITCH
MECH	MECHANICAL
MED	MEDIUM
MFR	MANUFACTURER
MIN	MINIMUM
MISC	MISCELLANEOUS
MM	MILLIMETER
MOD	MODIFY, MODIFICATION
MTBF	MEAN TIME BETWEEN FAILURE
MTD	MOUNTED
MTM	MAIN - TIE - MAIN (CIRCUIT BREAKERS)
MTTR	MEAN TIME TO REPAIR/RESTORE
N	NEUTRAL, NORTH
N/A	NOT APPLICABLE
NEC	NATIONAL ELECTRIC CODE
NEG	NEGATIVE
NEMA	NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION
NEMCC	NON-ESSENTIAL MOTOR CONTROL CENTER
NESB	NON-ESSENTIAL SWITCHBOARD
NFG	NOT FUNCTIONALLY GOOD
NFPA	NATIONAL FIRE PROTECTION ASSOCIATION
NI	NORMAL INPUT
NOM	NOMINAL

Acronym/Abbreviation	Definition
OD	OUTSIDE DIAMETER
OWS	OPERATOR WORKSTATION
PC	PERSONAL COMPUTER
PDU	POWER DISTRIBUTION UNIT
PF	POWER FACTOR
PH	PHASE
PLC	PROGRAMMABLE LOGIC CONTROLLER
PMCS	POWER MONITORING AND CONTROL SYSTEM
PNL	PANEL
POS	POSITIVE
PSG	PARALLELING SWITCHGEAR
PSI	POUNDS PER SQUARE INCH
PT	POTENTIAL TRANSFORMER
PWR	POWER
PZ	POWER ZONE
QTY	QUANTITY
REF	REFERENCE
REV	REVISION
RH	RIGHT HAND
RIO	REMOTE INPUT OUTPUT
RM	ROOM
RPM	REVOLUTIONS PER MINUTE
SA	SURGE ARRESTER
STS	STATIC TRANSFER SWITCH
SB	SWITCHBOARD
SCHED	SCHEDULE
SECT	SECTION
SG	SWITCHGEAR
SGL	SINGLE
SOW	STATEMENT OF WORK
SPD	SURGE PROTECTION DEVICE
SPEC	SPECIFICATION
SQ	SQUARE
SQ FT	SQUARE FEET
STA	STATION
SW	SWITCH
T	TRANSFORMER
TBD	TO BE DETERMINED
TEMP	TEMPERATURE
THD	TOTAL HARMONIC DISTORTION
TMDE	TEST MEASUREMENT AND DIAGNOSTICS EQUIPMENT
TRACON	TERMINAL RADAR APPROACH CONTROL
TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR

Acronym/Abbreviation	Definition
TYP	TYPICAL
UL	UNDERWRITERS LABORATORIES
UPS	UNINTERRUPTIBLE POWER SYSTEM
V	VOLT/VOLTAGE
VM	VOLT METER
W	WATT
WBS	WORK BREAKDOWN STRUCTURE
WT	WEIGHT
Z	IMPEDANCE

APPENDIX B—REPORT TEMPLATE FOR STUDIES

This appendix provides a report template for the Short Circuit, Load Flow, and Protective Device Coordination studies. This sample is provided in SKM Power Tools but Engineer shall provide studies in EDSA format. An electronic copy of the report template shall be made available with the Design Guidelines.

APPENDIX C—MANUFACTURER'S DOCUMENTATION

C.1 TBD GENERATOR EQUIPMENT

GENERATOR

- Refer to Volume 3 of TI6480.3, CPDS

AUTOMATIC TRANSFER SWITCH

- Refer to Volume 8, Part 1, Book 1 of TI6480.3, CPDS

C.2 EATON EQUIPMENT

UNINTERRUPTIBLE POWER SUPPLY

- Refer to Volume 6 of TI6480.3, CPDS

C.3 L–3 EQUIPMENT

STATIC TRANSFER SWITCH

- Refer to Volume 7 of TI6480.3, CPDS

C.4 SQUARE D EQUIPMENT

SWITCHBOARDS

- Refer to Volume 2, Part 1, Book 1 of TI6480.3, CPDS
- For shop drawings, refer to Square D drawings provided with this design guide.

PANELBOARDS

- Refer to Volume 5, Part 1, Book 1 of TI6480.3, CPDS
- For shop drawings, refer to Square D drawings provided with this design guide.

I-LINE PANELBOARDS

- Refer to Volume 5, Part 1, Book 1 of TI6480.3, CPDS
- For shop drawings, refer to Square D drawings provided with this design guide.

C.4 RAYVOSS EQUIPMENT

SURGE PROTECTION DEVICES

- Refer to Volume ??, Part ??, Book ?? of TI6480.3, CPDS

APPENDIX D—CONSTRUCTION SPECIFICATIONS

Specifications attached are a sample document and Design Engineer shall update and modify them to fit their specific application. These specification requirements are minimum standards allowed and more stringent local, state or federal requirements shall be followed.

DIVISION 2 - SITE CONSTRUCTION

SECTION 02555 - EXTERIOR FUEL DISTRIBUTION

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13080 - SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT

DIVISION 15 - MECHANICAL

SECTION 15491H - FUEL-OIL SYSTEM

DIVISION 16 - ELECTRICAL

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

SECTION 16070 - SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

SECTION 16075 - ELECTRICAL IDENTIFICATION

SECTION 16081 - APPARATUS INSPECTION AND TESTING

SECTION 16231 – INSTALLATION OF PACKAGED ENGINE GENERATOR

SECTION 16402 — INTERIOR DISTRIBUTION SYSTEM

SECTION 16410 — INSTALLATION OF AUTOMATIC TRANSFER SWITCHES

SECTION 16412 — INSTALLATION OF STATIC TRANSFER SWITCH

SECTION 16442 — INSTALLATION OF SWITCHBOARDS

SECTION 16461 – INSTALLATION OF DRY TYPE TRANSFORMERS (600V AND LESS)

SECTION 16610 – INSTALLATION OF UNINTERRUPTIBLE POWER SUPPLY SYSTEMS – SINGLE MODULE

SECTION 16910 –EPMS LAN CABLE PLANT

APPENDIX E—DRAWINGS

E 1 DRAWING LIST

Drawing Number	Drawing Title	Design Drawing	Reference Drawing
E001	General Symbols and Abbreviations	√	
E200	Typical Base Building Electrical Rooms Layout		√
E411	Equipment Description – Type 1		√
E440	Electrical Single Line Diagram – Type Basic	√	
E501	Electrical Details	√	
E502	Electrical Details	√	
E640	Switchboard and Panelboard Elevations – Type Basic	√	
E710	Panel Schedules – Type Basic		√
E711	Panel Schedules – Type Basic		√
E712	Panel Schedules – Type Basic		√
E800	Electrical EPMS Wiring Diagram – Type Basic		
E810	Electrical EPMS Details – Type Basic		
E901	Signage and Labeling Example	√	
E910	Signage and Labeling Standards – Type 1		√
E911	Signage and Labeling Equipment Naming – Type Basic		√

Only Design Drawings are Part of the Design Guide.

The Reference Drawings shall be reviewed by Design Engineer to incorporate all design aspects and adapted to each site as applicable. These reference drawings shall be used by the design engineer to develop equipment layouts, grounding, signage, fuel systems, etc.